Technical Memo

ARGONNE NATIONAL LABORATORY

ANL/EES-TM-177

DESCRIPTION OF ALTERNATIVE POLICIES FOR THE PRODUCTIVE CONSERVATION OF ENERGY IN URBAN TRANSPORTATION

Center for Transportation Research

Energy and Environmental Systems Division
ARGONNE NATIONAL LABORATORY

prepared for
U. S. DEPARTMENT OF ENERGY
under Contract W-31-109-Eng-38

The facilities of Argonne National Laboratory are owned by the United States Government. Under the terms of a contract (W-31-109-Eng-38) among the U. S. Department of Energy, Argonne Universities Association and The University of Chicago, the University employs the staff and operates the Laboratory in accordance with policies and programs formulated, approved and reviewed by the Association.

This informal report presents preliminary results of ongoing work or work that is more limited in scope and depth than that described in formal reports issued by the Energy and Environmental Systems Division.

Printed in the United States of America. Available from National Technical Information Service, U. S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne, Illinois 60439

ANL/EES-TM-177

DESCRIPTION OF ALTERNATIVE POLICIES FOR THE PRODUCTIVE CONSERVATION OF ENERGY IN URBAN TRANSPORTATION

by

Sarah J. LaBelle, Darwin G. Stuart,* and Larry R. Johnson

Energy and Environmental Systems Division
Center for Transportation Research

September 1981

work sponsored by
U.S. DEPARTMENT OF ENERGY
Assistant Secretary for Environmental Safety,
Protection, and Emergency Preparedness
Office of Environmental Analyses

---

*Barton-Aschman Associates, Inc., Evanston, Illinois

CONTENTS

TABLES

TABLES (Cont'd)

FIGURES

FOREWORD

Transportation directly consumes one quarter of the energy used in this country, with auto passenger travel accounting for half of the transport sector's energy use. Due to rising fuel prices and intermittent shortages, agencies of federal, state, and local governments have begun to introduce various strategies (combinations of policies and technologies) designed to conserve urban-transporation energy while maintaining a productive economy. The environmental consequences of many of these conservation strategies have not been adequately assessed. As a result, a technology assessment project sponsored by the U.S. Department of Energy, under the direction of David O. Moses, was initiated at Argonne National Laboratory in late 1979, with assistance from Brookhaven and Oak Ridge National Laboratories.

This project, Technology Assessment of Productive Conservation in Urban Transportation (TAPCUT), had the stated goals of providing (1) a description of several alternative strategies promoting energy conservation in urban passenger transportation, (2) a better understanding of the environmental impacts of such strategies, and (3) identification of the constraints on the implementation of such strategies.

Two productive conservation strategies were designed to save energy in urban passenger transportation when substituted for policies now in place. A reference set of impact forecasts was then prepared for these two strategies. One conservation strategy stressed group travel, e.g., mass transit and carpooling, while the other promoted individual travel in private automobiles. The strategies were designed to cause minimal disruption of lifestyles and the economy while achieving reductions in the consumption of aggregate energy, especially that derived from petroleum.

Travel demand analysis was performed for each of three typical cities under policies now in place and forecast to continue, and under the alternative strategies, i.e., Group Travel Strategy and Individual Travel Strategy. Environmental impact analysis of the forecast travel demand under each strategy was city-specific and included estimation of air and water pollutant burdens along with their associated impacts on human health. Traffic safety impacts were also estimated. Socioeconomic impacts due to vehicle use and vehicle production were assessed. Impacts on physical environment, resources, health, and safety caused by vehicle and fuels production and infrastructure construction were also addressed. The final step was the overall comparison of policy-driven results to the results obtained under the In-Place Policy set.

Two economic and social-organization scenarios also were defined for this project; they differed in GNP growth rate, social organization, retail fuel price, total metropolitan population, average household income, environmental regulations, and types of fuel available for transportation. The two scenarios can be briefly distinguished as Scenario I, a wealthy economy with high technological success, and Scenario III, a relatively poor economy with low technological success. National urban and city-specific forecasts of population and employment characteristics were prepared under each scenario.

The cities were selected using a factor-analysis technique that identified extreme cities along three dimensions relevant to transportation energy use. One dimension, called Megatown, identifies large cities with good transit systems. The second dimension, Sprawlburg, typifies newer, fast-growing, sprawl cities. The Slowtown dimension identifies midwestern industrial cities that are smaller in population than the other two. All metropolitan areas in the nation were related to these three dimensions; an expansion method was then developed to allow national urban forecasts to be made based on the detailed forecasts of the three typical cities selected to represent each dimension.

Automobile and transit vehicle characteristics were projected in detail under several sets of policy and scenario conditions. Three different sets of vehicles were used in the analysis: Set C, the expected technologies, was used for the In-Place Policy and Group Travel Policy in both scenarios; Set A, designed as the best technology for both conservation and performance, was tested for the Individual Travel Policy in one scenario; the third set, a modification of Set C, was tested in the other scenario under the Individual Travel Policy. Vehicles were characterized by size class, engine type, fuel economy, emissions profile, purchase price, operating costs, materials composition, and (for personal vehicles) performance.

The city-specific forecasts were organized for input to the Urban Transportation Policy Analysis Package. It incorporated state-of-the-art, household-based, disaggregate travel demand models for mode and destination choice with detailed specification of individual household auto ownership by automobile technology. Household characteristics from the base year in each city's travel survey were the basis of the approach to forecasting travel demand. Household records modified for each scenario, combined with the transportation level-of-service forecasts, which varied by policy, for the horizon years 1990 and 2000 drove the travel demand model. Transportation level-of-service parameters included detailed specifications of transit service and automobile characteristics. Both work and nonwork travel are separately forecast and reported for households in three income classes and for three locations within the urban area (center city, suburban, and exurban). Vehicle travel is also reported by area of occurrence for the air emissions and traffic safety analysis.

Results for the entire TAPCUT project will be presented in a final report. The technical memorandum that follows is one in a series of TAPCUT working papers that was selected for publication as a separate document to supplement the final report. The topic covered here is considered to be of interest to certain researchers/users who would not need to explore the full scope of TAPCUT. Conversely, the detail of presentation herein is inappropriate for the project's final report.

The two productive conservation strategies or policies are described in this report in terms of levers, i.e., specific variables to be changed in the modeling studies. These levers were grouped into five categories: (1) land use controls, (2) fuels/vehicles research and development, (3) economic/regulatory disincentives for auto travel, (4) group travel incentives, and (5) auto travel behavioral change. Each category includes several levers. For example, increased fuel taxes and increased parking taxes are included in economic regulatory disincentives for auto travel, whereas reduced transit fares and increased transit service frequency are used as group travel incentive levers. Values are specified for each lever. For the In-Place Policy, 1980 values are simply projected to 1990 and 2000, whereas for the Group Travel and Individual Travel, the rationale is given for the values specified.

The policies are first described in this report as they were specified at the March 1981 Meeting of the TAPCUT Project Review Panel and then as they were actually tested in the model packages. Differences from the original specifications occurred when no methods could be found to model certain proposed policy actions and likely responses to them, or when two or more policy actions were reflected in changes to the same policy lever.

fares and increased transit service frequency are used as group travel incentive levers. Values are specified for each lever. For the In-Place Policy, 1990 values are simply projected to 1990 and 2000, whereas for the Good Travel and Individual Travel, the particular increases for each value specified.

The policies are first described in this report as they were specified at the March 1990 meeting of the TARCUT Project Review Panel and then as they were actually tested in the model packages. Differences from the original specifications occurred when no methods could be found to model certain proposed policy actions and likely responses to them, or when two or more policy actions were reflected in changes to the same policy lever.

DESCRIPTION OF ALTERNATIVE POLICIES FOR THE PRODUCTIVE CONSERVATION OF ENERGY IN URBAN TRANSPORTATION

by
Sarah J. LaBelle, Darwin G. Stuart, and Larry R. Johnson

1 INTRODUCTION

This report describes two energy conservation strategies (or policies) that were developed in order to estimate the environmental impacts of changes in energy use for urban transportation by the year 2000. The In-Place Policy, which assumes an extension of all programs and plans in place in 1980 that affect urban transportation, is also described; this policy is used to provide reference information against which to compare the two alternative conservation strategies -- the Group Travel Policy and the Individual Travel Policy. The strategies were first developed at a Technology Assessment of Productive Conservation in Urban Transportation (TAPCUT) Project Review Panel meeting in March, 1981. After the alternative strategies were approved by the panel, their impacts were forecast in modeling studies using a travel demand model, a household auto ownership model, and household location forecasts for the TAPCUT project, as described in the Foreword. These strategies (or policies) represent two different approaches to saving energy in urban transportation. The Group Travel Policy emphasizes behavioral changes (increased use of mass transit and carpooling) with minimal emphasis on changes to vehicles. In contrast, the Individual Travel Policy focuses on improvements in automobile technology as the primary means to conserve transportation energy but maintain mobility.

Two scenarios, I and III, that describe different economic/social futures were used to define the characteristics of the policies. These scenarios, as mentioned in the Foreword, are distinguished from each other by a variety of factors, among which are (1) the rate of GNP growth, (2) the rate of fuel price increases, (3) the degree of success in the development of technology, and (4) the level of social organization. In all cases, Scenario I assumes greater growth and more highly developed technology than does Scenario III. A higher percentage of the national population is assumed to live in metropolitan areas in Scenario I than in Scenario III. (Another scenario, II, was initially included, but later dropped from the analyses.)

Five categories of individual conservation actions were used to define each policy; these categories and actions are listed in Table 1, with the specific policy lever used in the models enclosed in parentheses beside each listing. The amount of change in the policy lever for each of these actions is presented as a percentage of the value that would be specified for the In-Place Policy. The five categories of actions -- (1) land use controls, (2) fuels/vehicles research and development, (3) economic/regulatory disincentives for auto travel, (4) group travel incentives, and (5) automobile travel behavioral changes -- form the outline for this report. Chapters 2-6 describe the individual actions for the strategies and scenarios as they were tested under each of the three policies: In-Place, Group Travel, and Individual Travel. Modifications of the actions that occurred as the analyses progressed are also noted in the chapters. The values in Table 1, and throughout the other chapters, are reported as national urban changes in the policy levers. When the policy levers were applied at the typical city level, the national change was derived as a weighted average of the policy lever changes tested on each typical city. The expansion method mentioned in the Foreword provided the weighting. The typical cities were selected for their differences in transportation and energy-related characteristics. Therefore, when each policy was tested in the different cities, the same numerical values for the policy levers were not always used.

Chapter 7 summarizes the modifications to the policies made during the TAPCUT analyses and tabulates the resulting changes in conservation projections.

Table 1 Energy Conservation Policies as Drafted at the March 1981 Meeting of TAPCUT Project Review Panel

Individual Conservation Actions (Policy Levers)	% of In-Place Policy Value: Under Group Travel Policy, Scenario I	Under Group Travel Policy, Scenario III	Under Individual Travel Policy, Scenario I	Under Individual Travel Policy, Scenario III
Land Use Controls				
Live close to work (work trip length)		-15		-15
Increase high-density zoning (number of households relocated near/away from centers)		50[a]		50
Provide decentralized work and shopping locations (employment growth relocated near/away from population centers)		No change		50
Promote CBD[b] growth (CBD percentage of total employment)		25		No change
Fuels/Vehicles R&D				
Use telecommunications substitution (work and nonwork trip generation)[c]	-15		-25	-15
Increase R&D on vehicle weight (average new car weight)			-30	-20
Increase engines/fuels R&D (new car mpg)	15		30	10
- Increase use of alcohol fuel blends				
- Increase Otto cycle R&D				
- Increase diesel vehicle and fuel R&D				
- Increase electric vehicle R&D				
- Increase advanced heat engines R&D				
Economic/Regulatory Disincentives for Auto Travel				
Increase gas and parking taxes (increase in auto out-of-pocket travel costs)				
- Increase CBD daily parking cost	200	200		
- Increase gas tax (net effect on fuel price)	100[d]	50[d]		
- Tax existing parking supply (increase in parking cost)	100[e]	50[e]		
Increased vehicle maintenance (increase in average mpg)	No change	4		
Increase post-1985 CAFE[f]; Impose gas guzzler tax (fleet average new car mpg)	No change	5		
Provide vehicle tax/rebate (fleet average new car mpg)	10	5		
Group Travel Incentives				
Provide carpool/vanpool promotion and incentives (number of carpools available)	60	60		
Improve express bus service (travel times)	40	20		
Improve conventional bus service (travel times)	No change	15		
Improve rail transit service (travel times)	60	No change		
Reduce transit fares	No change	25		
Automobile Travel Behavior Change				
Trip linking for work and nonwork (reduced trip generation and trip length)	35	35		
Decrease auto ownership (number of autos/household for multicar households)	25	25		

[a]Reallocate residential growth within express transit corridors.

[b]Central Business District.

[c]Exact change percent subject to refinement.

[d]Increase in pump price per gallon; to be converted to increase in automobile out-of-pocket cost.

[e]Where parking is free, add a base daily cost of $2 (Scenario I) or $1 (Scenario III).

[f]Corporate Average Fuel Economy.

2 LAND USE CONTROLS

The major purpose of this category of actions is to decrease travel by shifting population and/or employment locations. The individual actions as considered under each policy are discussed below.

2.1 IN-PLACE POLICY

Under the In-Place Policy, most population growth was presumed to occur in the suburban ring of each typical city. The central business district (CBD) lost population in absolute terms in all three cities. Under Scenario I, the CBD's percentage of total employment decreased slightly; under Scenario III, it decreased significantly. In Scenario I, in the rapidly growing Sprawlburg, the CBD's share of employment dropped as much as 21%, but the absolute level of employment increased. In Megatown, under both scenarios, the CBD's percentage of employment decreased, but the absolute employment increased slightly under Scenario I. Slowtown lost CBD employees under both scenarios. Absolute urban populations increased in the newer city, Sprawlburg, but decreased in the two older cities.

In Scenario I, relative to Scenario III, population density and employment were increased in all cities. Megatown had a higher rate of growth in Scenario I; Sprawlburg, however, grew more rapidly in Scenario III. All three cities showed less growth in the exurban ring in Scenario I than in Scenario III. Growth in the exurban ring, however, did occur under both scenarios in all three cities.

2.2 GROUP TRAVEL POLICY

Under this policy, changes were modeled only in Scenario III. Increased emphasis on high-density zoning in all of the cities produced more high-density residential areas than were projected under the In-Place Policy. About 5% of the growth in households in 1990 (10% in 2000) in each prototypical city was relocated in this manner. Employment growth was shifted closer to the population centers in each city -- with a >28% shift occurring each forecast year. Retail employment shifts paralleled general employment shifts. Even though these shifts in residential and employment growth accounted for a reasonably large percentage of the employment growth, the net change was small when absolute levels of employment and numbers of households were considered.

The CBD received a larger share of regional employment growth under this policy than under the In-Place Policy, slowing or halting the current trend of decreasing the CBD's share of total employment. The fast-growing city, Sprawlburg, increased the absolute level of CBD employment by 53% from 1980 to 2000, as compared with 36% under the In-Place Policy. Megatown lost less CBD employment under this policy than under the In-Place Policy, dropping the share only two percentage points from 1980 to 2000. The changes in Slowtown were smaller; the CBD's share dropped by 36% instead of by 45%, which meant a 15% increase in employees over the projections under the In-Place Policy.

The average work trip length was decreased by 14%. (The iterative proportional fitting process[1] developed for the TAPCUT project was used in this determination.) This decreased trip length represents the results of actions tending to have people commute shorter distances. Policies that would induce the shorter work trips are not described in any detail because it is their effect that is most easily measured. It is not clear from the literature exactly which actions will have this effect. Candidate actions are (1) removing income tax credits for automobile use, (2) increasing transportation costs relative to other household expenses, (3) changing housing costs by providing tax credits for living close to work, and (4) moving employer locations closer to concentrations of workers.

2.3 INDIVIDUAL TRAVEL POLICY

For this policy, again changes were modeled only in Scenario III, with residential growth and employment locations the focus of change. These changes occurred in the opposite direction from those shown under the Group Travel Policy. About 5% of the growth in households was relocated away from established population centers. In both 1990 and 2000, about 17% of new employment was relocated to less dense areas. The CBD share of regional employment dropped even faster under this policy than under the In-Place Policy. By 2000, employment in the CBD ranged from 4% to 12% of the total employment in the three typical cities. Fast-growing Sprawlburg, however, still showed growth in the absolute number of CBD employees.

No changes were made in work trip length, as that action was considered to be inconsistent with the Individual Travel Policy.

3 FUELS/VEHICLES RESEARCH AND DEVELOPMENT

The actions discussed here deal primarily with changes to vehicles that will provide more-efficient use of transportation energy.

3.1 IN-PLACE POLICY

A reference set of vehicles was designed for use in both scenarios;[2] the fuel economies of these vehicles are shown in Table 2. There was some variation in the fleets (holdings of all cars by households) between scenarios, entirely because of different household characteristics in each that lead to preferences for different cars. New car purchases varied by scenario because of the different household characteristics and because of the different cost of money assumed in each scenario (8% in Scenario I; 12% in Scenario III).

Vehicle weight reduction (from 1980 weights) is assumed for each of three size classes. Reductions are approximately 16% for small vehicles, 27% for medium-size vehicles, and 21% for large vehicles.

No explicit assumptions were made about the use of telecommunication or its substitutability for urban transportation in the In-Place Policy. Thus, whatever relationship exists now is assumed in the forecasts.

3.2 GROUP TRAVEL POLICY

Only relatively minor actions were taken in this policy for both scenarios. No changes because of altered use of telecommunications were modeled. No models were found to estimate travel responses to increased

Table 2 Automobile Fuel Economy under the In-Place Policy

Type of Vehicle used in Model	Scenario	Fuel Economy (mpg) 1980	1990	2000	Change from 1980 to 2000 (%)
New Cars	I	23.1	27.5	32.0	38.5
	III	23.1	27.6	33.0	42.9
Holdings	I	16.1	23.0	29.5	83.3
	III	16.1	23.1	29.4	82.6

[a]Computed using Environment Protection Agency's CAFE method, with 55%/45% rural/urban split for driving.

availability and use of telecommunications. Development of a suitable theory requires better data than are currently available. (At present, arguments for increases in travel due to increased telecommunications are just as convincing as arguments for decreases in travel. Historically, the introduction of the telephone has not provided a solution for urban traffic jams. In fact, travel per capita increased during the period of increasing telephone use.)

Automobile fleets were modestly changed in both scenarios. The medium-sized vehicle with an Otto (spark ignition) engine was replaced by a car with a more-competitive design, and the net effect on fleet fuel economies is displayed in Table 3. Research to decrease vehicle weight was not stressed in this policy; in fact, under both scenarios, medium-sized cars were 3-4% heavier by 2000, and the weights for other size cars were unchanged. Further analysis of the Group Travel Policy led to the conclusion that significant weight reductions and fuel economy increases were inappropriate to the basic approach of the policy.

3.3 INDIVIDUAL TRAVEL POLICY

Relatively large changes in vehicles were introduced in Scenario I, which assumed the most efficient fleet with good performance (measured by acceleration) possible by 2000. More-modest improvements were included in Scenario III assumptions. Table 4 displays the national urban fuel economy projected under this policy.

In Scenario I, by 2000, the Li/S battery electric cars were added and Pb/acid battery cars dropped. The Stirling (external combustion) engine was introduced in 2000. No new technology was introduced in Scenario III; improvements merely occurred in the same types of vehicles as existed under the In-Place Policy, reflecting the lower level of technology success characteristic of Scenario III. The weight reductions achieved in vehicles under each scenario are shown in Table 5.

Table 3 Automobile Fuel Economy under the Group Travel Policy

Type of Vehicle used in Model	Scenario	Fuel Economy (mpg) 1990	2000	Change from 1980 to 2000 (%)	Change from In-Place in 2000 (%)
New Car	I	28.1	32.9	42.4	2.8
	III	28.1	32.4	40.3	-1.8
Holdings	I	25.3	30.2	87.6	2.4
	III	23.9	30.2	87.6	2.7

Table 4 Automobile Fuel Economy under the Individual Travel Policy

Type of Vehicle used in Model	Scenario	Fuel Economy (mpg) 1990	Fuel Economy (mpg) 2000	Change from 1980 to 2000 (%)	Change from In-Place in 2000 (%)
New Cars	I	35.3	39.5	71.0	23.4
	III	27.2	34.2	48.1	3.6
Holdings	I	26.9	36.2	124.8	22.7
	III	23.4	31.3	94.4	6.5

Table 5 New Vehicle Weights under the Individual Travel Policy

Vehicle Size	Scenario	Vehicle Weight (lb) 1990	Vehicle Weight (lb) 2000	Change from 1980 to 2000 (%)	Change from In-Place in 2000 (%)
Small	I	1923	1669	-29.0	5.0
Medium		2511	2210	-29.0	3.4
Large		3011	2558	-31.1	-22.9
Small	III	1968	1828	-22.2	-7.1
Medium		2594	2405	-22.9	+5.2
Large		3080	2766	-25.5	-5.8

The share of the market projected for the medium-sized vehicle by 2000 dropped dramatically. Prior purchasers of medium-sized vehicles apparently found them too heavy for the energy and performance benefits relative to other vehicles on the market, and no new consumers found them desirable either. The medium-sized vehicle was originally designed for those who could not afford the luxurious large cars, but needed more space than found in small cars. This market apparently opted for small cars instead. For Scenario I, the net change in new car weights was a 10% reduction, including the effect of new car sales distribution. For Scenario III, the net change was a 3% reduction.

In contrast to the 30% increase in fuel economy with respect to the In-Place Policy for Scenario I (10% for Scenario III) proposed in Table 1, the Individual Travel Policy actually tested a 23% increase for Scenario I and a 7% increase for Scenario III by 2000. The weight changes tested (in contrast to In-Place Policy) were 10% and 3%, against the 30% and 20% suggested in Table 1. One reason for this difference from the original proposal is that fuel economy improvements eventually require very significant decreases in vehicle performance. Vehicles characterized for the TAPCUT project maintain reasonable performance (power/weight), particularly in Scenario I. This requirement puts an initial constraint on their design. In addition, many fuel economy improvements occur through changes in engine design, which have little or no effect on weight or performance. Further, the choices made by households among vehicles types are biased toward vehicles that perform well and carry some minimum number of passengers. The two-passenger automobile (the mini) characterized in all forecasts was not a favorite choice because of its limited passenger capacity and the inertia built into the household auto ownership model against that choice. Choice of the mini car would have greatly increased fuel economy. In Scenario I, as mentioned above, vehicle type preferences had a damping effect on weight reduction. In Scenario III, market preferences resulted in an increase in average fleet car weight, in spite of reductions in the weight of each car type as compared with the weights modeled for the In-Place Policy.

These fuel economy values, given in Tables 2-4, are actual values for the vehicles held or purchased in that year, rather than benchmark values reflecting supplier offerings to households. The benchmark values are explained and presented in Ref. 2. Further, the values presented here for new cars are comparable to corporate-average-fuel-economy values, as the rural fuel economy is included. Fuel economy specific to the driving in the nation's urban areas is estimated in Ref. 3.

4 ECONOMIC/REGULATORY DISINCENTIVES FOR AUTO TRAVEL

The primary effect of the actions modeled in this section is to decrease vehicle use, thereby conserving transportation energy.

4.1 IN-PLACE POLICY

Parking costs and fuel taxes were used as the primary disincentives under the In-Place Policy. As the modeling studies are conducted using constant dollars, increases in regulations to keep parking costs and fuel taxes in their current proportions with respect to income are assumed. This assumption is in line with all recent writings on the minimum expected change in fuel taxes, both state and national. The projected fuel taxes are shown in Table 6 in both 1975 dollars and as a percentage of the fuel price. No new parking taxes were assumed for this policy (i.e., charges were assumed only for the CBD).

4.2 GROUP TRAVEL POLICY

Substantial changes in parking and fuel taxes were postulated for this policy. The other three actions listed in Table 1 are presumed to be primarily implementation tools needed to keep manufacturers producing vehicles to meet the sales-weighted fuel economy standards and are presumed to cause no further changes in new vehicle fuel economy, beyond those described in the preceding section.

The change in fuel tax is shown as a percentage of the retail fuel price in Fig. 1 and in 1975 dollars in Fig. 2. Table 7 presents the retail price for fuel (in 1975 dollars) projected under both this policy and the In-Place Policy, summing the tax and the dealer's price.

Diesel fuel prices were slightly lower than gasoline prices, but always changed in concert with the gasoline prices.

Parking charges were significantly restructured. Existing CBD charges were tripled in both scenarios. In Scenario I, remaining existing fees were doubled (e.g., fees for satellite city business districts) and a base daily charge of $2.00 (1975 dollars) was introduced for all other parking. In

Table 6 Fuel Taxes under the In-Place Policy

Tax	Scenario	1975	1980	1990	2000
1975 $/gal	I	0.14	0.14	0.14	0.14
% of Fuel Price		33.8	20.7	9.3	7.4
1975 $/gal	III	0.14	0.14	0.14	0.14
% of Fuel Price		33.8	20.7	8.0	5.5

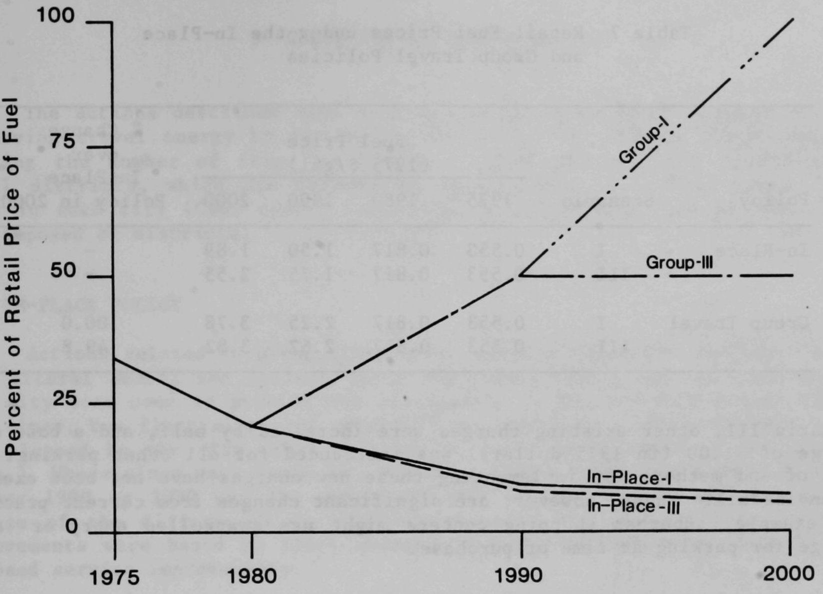

Fig. 1 Changes in Fuel Taxes under the Group Travel Policy by Scenario from 1975 to 2000

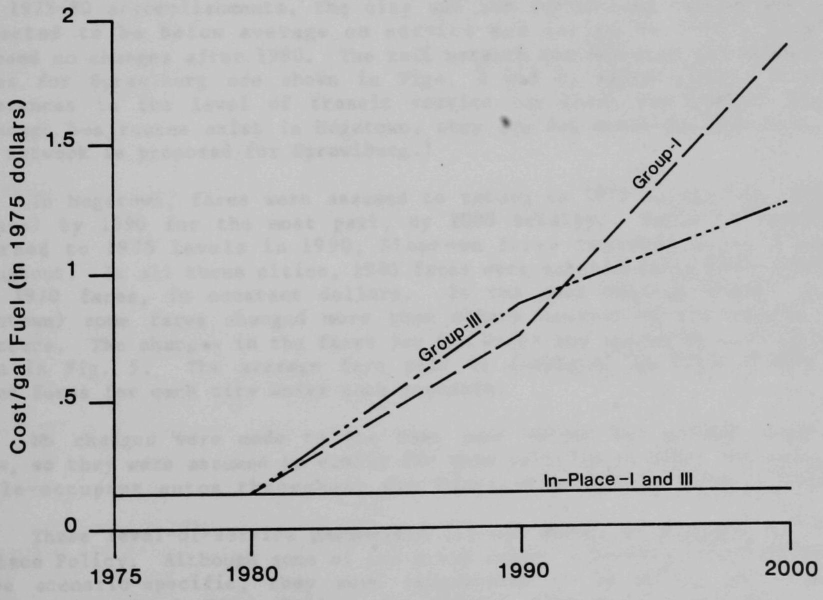

Fig. 2 Amount of Automobile Fuel Tax by Scenario from 1980 to 2000

Table 7 Retail Fuel Prices under the In-Place and Group Travel Policies

Policy	Scenario	Fuel Price (1975 $/gal) 1975	1980	1990	2000	% Change over In-Place Policy in 2000
In-Place	I	0.553	0.817	1.50	1.89	-
	III	0.553	0.817	1.75	2.55	-
Group Travel	I	0.553	0.817	2.25	3.78	100.0
	III	0.553	0.817	2.62	3.82	49.8

Scenario III, other existing charges were increased by half, and a base daily charge of $1.00 (in 1975 dollars) was introduced for all other parking. The cost of and methods for implementing these new charges have not been examined in any detail. These, however, are significant changes from current practice; for example, suburban shopping centers might use controlled entry or levy a charge for parking at time of purchase.

4.3 INDIVIDUAL TRAVEL POLICY

No actions were proposed under this policy.

5 GROUP TRAVEL INCENTIVES

The actions described here were all designed to promote group travel, conserving travel energy by decreasing the number of vehicle trips, without changing the number of trips by persons. These actions were specified by travel districts, which are defined as aggregations of traffic zones. The rings in each city (CBD, center city ring, suburban ring, and exurban ring) are composed of districts.

5.1 IN-PLACE POLICY

Actions related to group travel were defined under the In-Place Policy in a literal sense; the current five- and twenty-year plans for each prototype city were used to provide the information on bus and rail travel times, walk times, bus fleet size, and extent of bus service. (If new highway links were planned by the city, that information was also included in the projections.) Where plans were vague on completion dates, judgments were made as to whether 1990 or 2000 was the more realistic date to expect implementation. Because of the differences in planning methods used in each city, service improvements were based on fleet changes or fleet changes were deduced from proposed service improvements.

The three typical cities varied in their plans. Megatown was ambitious in rail extensions but modest in bus service changes. Sprawlburg proposed a big increase in bus fleet size and off-peak service coverage but, consistent with 1975-80 accomplishments, the city and its surrounding region are still projected to be below average on service per capita by 2000. Slowtown proposed no changes after 1980. The rail network for Megatown and express bus routes for Sprawlburg are shown in Figs. 3 and 4, which clearly show the differences in the level of transit service for these two typical cities. (Although bus routes exist in Megatown, they are too dense to show here. No rail network is proposed for Sprawlburg.)

In Megatown, fares were assumed to return to 1975 levels (in constant dollars) by 1990 for the most part, by 2000 totally. Fares in Sprawlburg returned to 1975 levels in 1990; Slowtown fares remained at 1975 levels throughout. In all three cities, 1980 fares were substantially below 1975 and even 1970 fares, in constant dollars. In the most complex transit system (Megatown) some fares changed more than others because of the complex fare structure. The changes in the fares for the major bus system in each city are shown in Fig. 5. The average fare paid is displayed in Table 8 with the posted fares for each city under each scenario.

No changes were made to the base year values for carpool times and costs, so they were assumed to remain the same relative to times and costs for single-occupant autos throughout the forecast period in both scenarios.

These level-of-service parameters did not change by scenario under the In-Place Policy. Although some of the group travel incentives could be argued to be scenario-specific, they were interpreted to be policy variables in TAPCUT. Under the In-Place Policy, the cities' plans were tested against the different futures described by the scenarios. However, some scenario

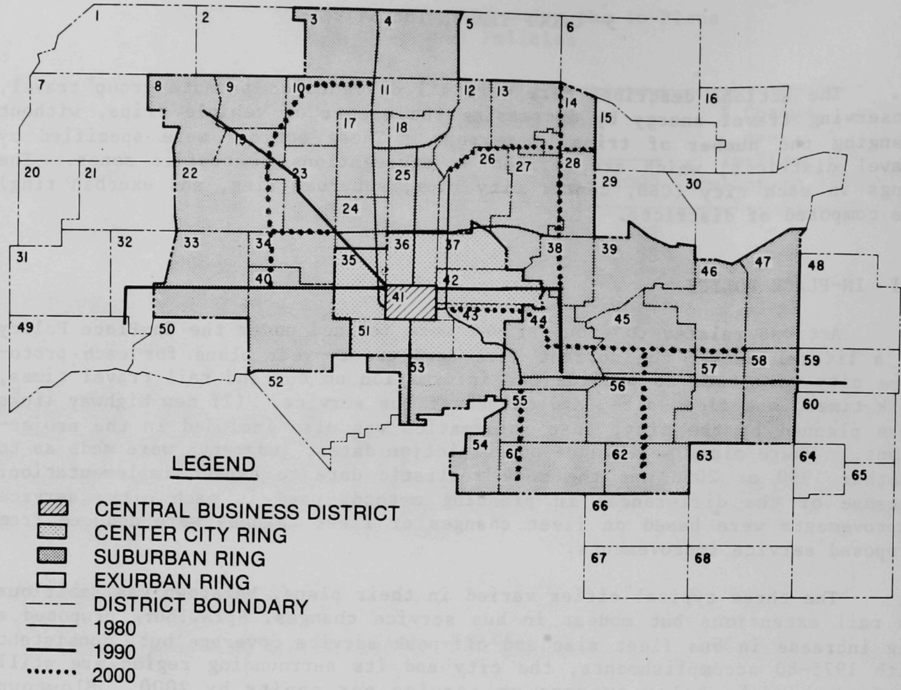

Fig. 3 Staging of Express Bus Routes in Sprawlburg under the In-Place Policy (the numbers in the figure refer to the individual travel districts)

variation was allowed in the alternative policies designed for TAPCUT, as sensitivity to scenario conditions is appropriate.

5.2 GROUP TRAVEL POLICY

All actions to promote group travel were included under the Group Travel Policy. In Scenario I, carpool incentives, additional express buses, improvements in conventional bus times and increases in rail transit (light and heavy) were all tested as proposed in Table 1. For Scenario III, all the same types of changes were made, except that rail changes were limited to large cities, conventional bus travel times were unchanged, and fares were reduced to 75% of the In-Place value.

There were substantial increases in transit service beyond current plans, especially in Scenario I. By typical city, the changes are summarized as follows. (It should be noted that these cities are viewed as typical for the TAPCUT project, although some effort was made to be consistent with the specific city's development and history.)

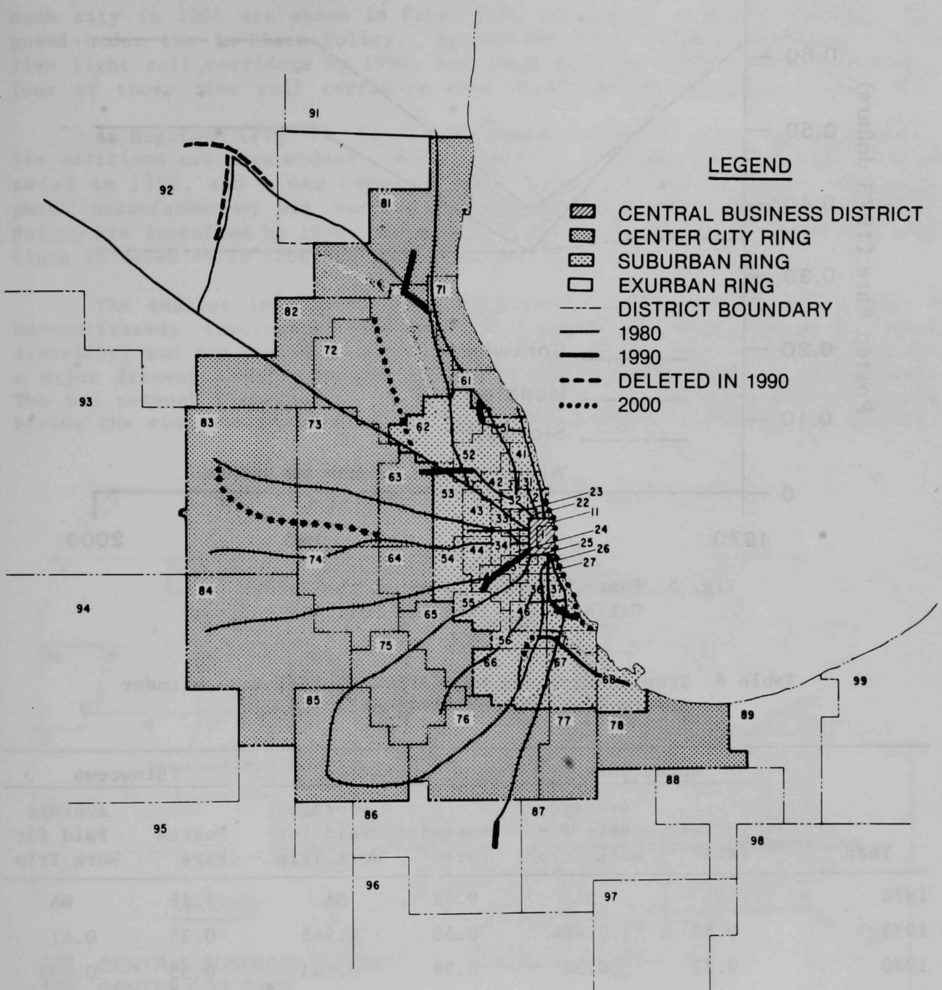

Fig. 4 Staging of Rail Construction in Megatown Under the In-Place Policy (the numbers in the figure refer to the individual travel districts)

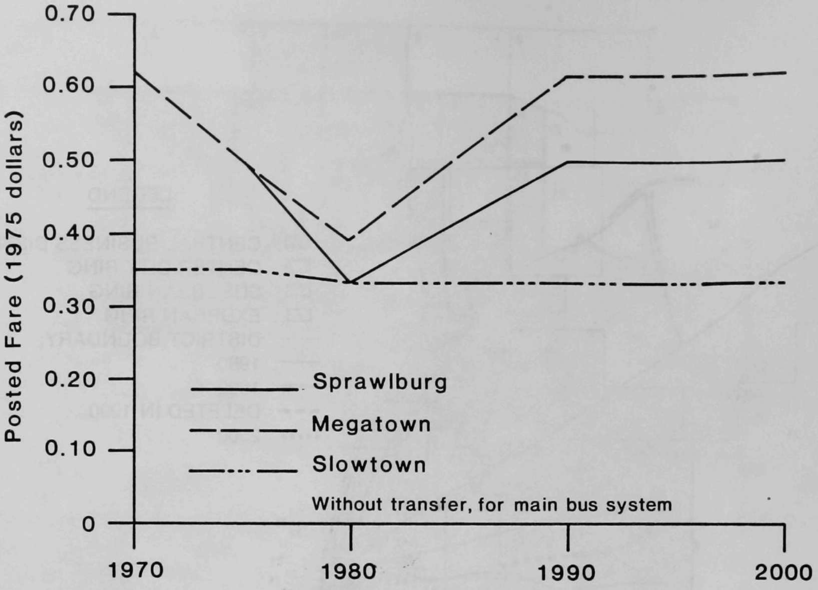

Fig. 5 Posted Transit Fares in the TAPCUT Cities under In-Place Policy

Table 8 Transit Fares in the TAPCUT Typical Cities under the In-Place Policy (1975 dollars)

Year	Sprawlburg		Megatown		Slowtown	
	Posted Fare[a]	Average Paid for Work Trip[b]	Posted Fare	Average Paid for Work Trip	Posted Fare	Average Paid for Work Trip
1970	NA	NA	0.62	NA	0.35	NA
1975	0.50	0.484	0.50	0.945	0.35	0.41
1980	0.33	0.38	0.39	0.543	0.33	0.393
Scenario I						
1990	0.50	0.504	0.62	1.06	0.33	0.394
2000	0.50	0.504	0.62	1.07	0.33	0.394
Scenario III						
1990	0.50	0.503	0.62	1.04	0.33	0.395
2000	0.50	0.502	0.62	1.04	0.33	0.396

[a]Without transfer, for main bus system.

[b]For all work travel, one-way cost including transfers, rail systems, from travel demand model results, i.e., weighted by trips taken rather than by service offered.

[c]NA = not available.

The Scenario I Group Travel rail and express bus transit networks for each city in 2000 are shown in Figs. 6-8, contrasted with the networks proposed under the In-Place Policy. Sprawlburg (Fig. 6) was postulated to add five light rail corridors by 1990, and three more by 2000. For Scenario III, four of those five rail corridors were developed as express bus corridors.

As Megatown (Fig. 7) is already characterized by good transit service, its additions are more modest. For Scenario I, a crosstown rapid rail line is added in 1990, and a new commuter rail line is added in 2000. The proposed urban/suburban bus service improvements for 2000 under the In-Place Policy are installed by 1990. In Scenario III, only one of the crosstown rail lines is added -- in 2000 instead of 1990.

The smaller industrial city, Slowtown (Fig. 8), in Scenario I adds a bus-on-freeway (exclusive bus lane) in two travel corridors (groups of travel districts) and one busway (separate roadway or right-of-way for buses) beside a major freeway. For Scenario III, only the bus-on-freeway is implemented. The bus network projected under the In-Place Policy includes several routes beside the ring route shown, which were omitted from the drawing for clarity.

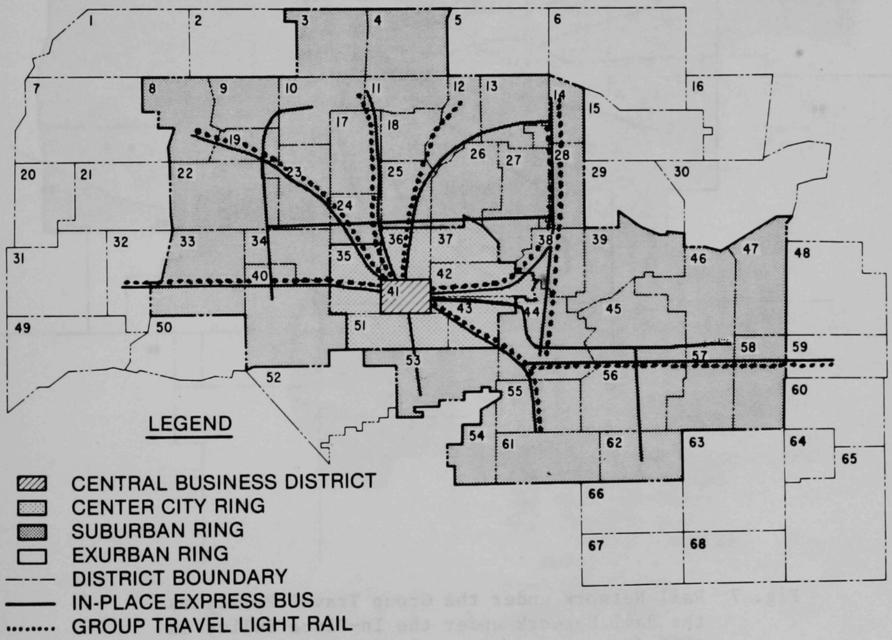

Fig. 6 Light Rail Network under Group Travel Policy vs. Express Bus Network under the In-Place Policy in 2000 for Sprawlburg (the numbers in the figure refer to the individual travel districts)

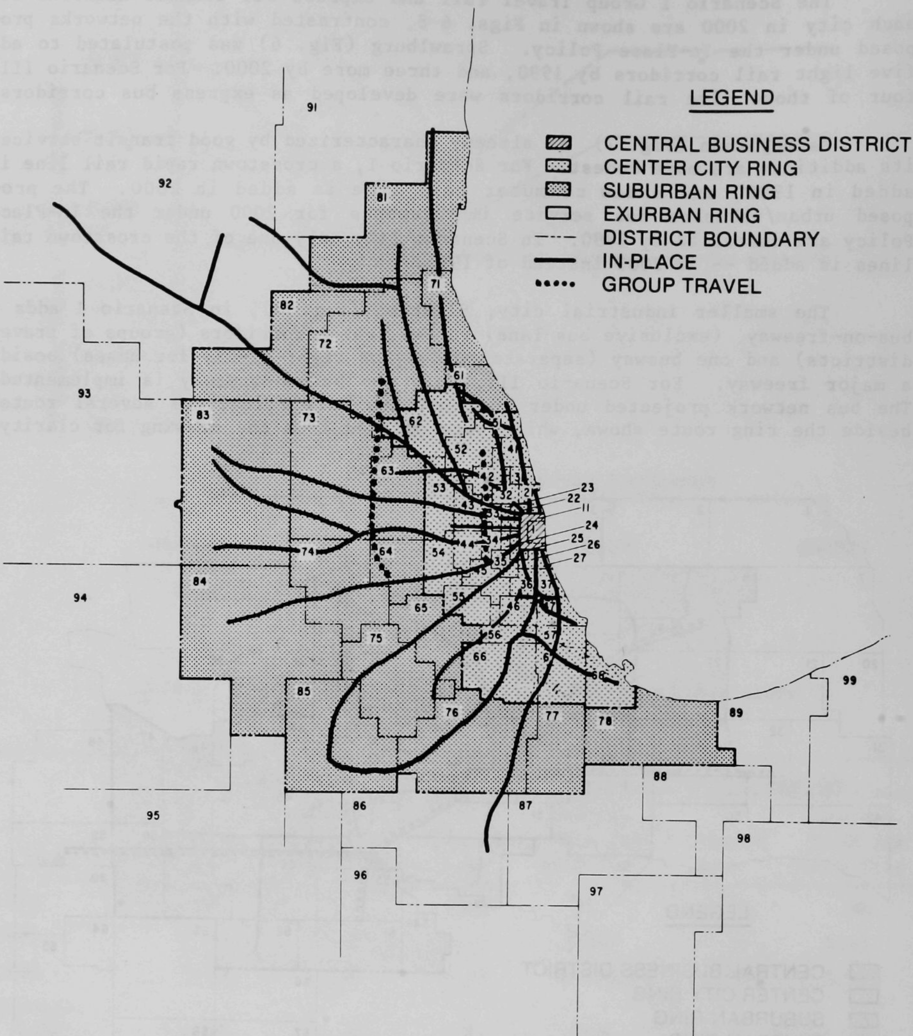

Fig. 7 Rail Network under the Group Travel Policy vs. the Rail Network under the In-Place Policy in 2000 for Megatown (the numbers in the figure refer to the individual travel districts)

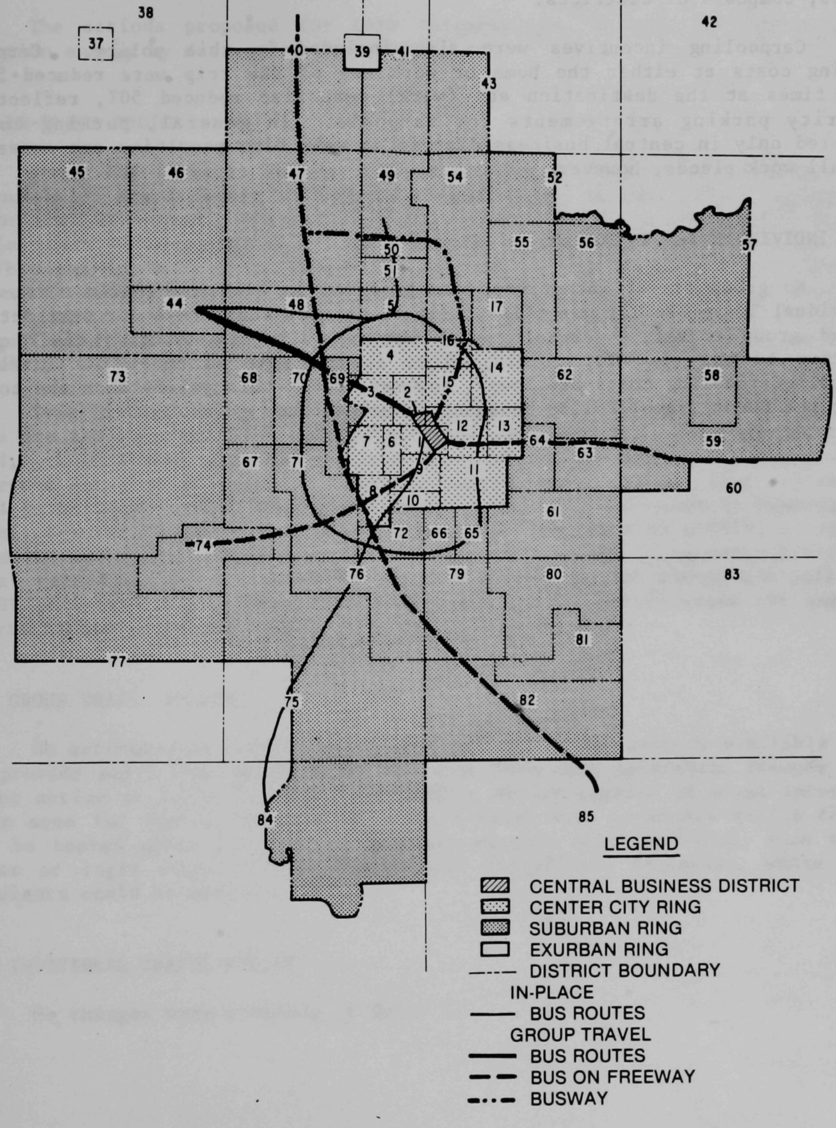

Fig. 8 Express Bus Routes under Group Travel Policy vs. the Bus Routes under the In-Place Policy in 2000 for Slowtown (the numbers in the figure refer to the individual travel districts)

For all three cities, the improvements in the overall bus wait time occur in Scenario I only. These improvements were defined in travel corredors, composed of districts.

Carpooling incentives were also included in this policy. Carpool parking costs at either the home or work end of the trip were reduced 50%. Walk times at the destination end (work) were also reduced 50%, reflecting priority parking arrangements for carpools. In general, parking costs occurred only in central business districts; walk time penalties are assessed for all work places, however.

5.3 INDIVIDUAL TRAVEL POLICY

No group travel incentives were provided in either scenario under the Individual Travel Policy, as this policy is neither supportive nor destructive toward group travel. Carpool costs were not directly changed; their cost relative to the cost for driving alone is the same as under the In-Place Policy. Carpooling costs are lower, however, under this policy than the costs under the Group Travel Policy because of fuel economy gains.

6 AUTO TRAVEL BEHAVIORAL CHANGE

The actions proposed for this category are designed to save transportation energy by decreasing automobile use.

6.1 IN-PLACE POLICY

Under the In-Place Policy, auto ownership is projected to change only as households are forecast to increase their income or make other changes in one or more demographic characteristics. (This process is part of the automobile stock holdings model.) Some changes are shown over time in average cars/households, but these changes depend only on the movement of households to new classes. There was no way to set a taxing policy that would influence only multicar households in the automobile stock holdings model with the categorical approach used by the TAPCUT project. That action (decrease auto ownership) in Table 1, therefore, was not tested.

Trip-linking is not directly considered in the In-Place Policy. Linked trips are not reported in a household travel record because they are not home based. Theoretical work is required to develop a method to forecast this important category of travel. Based on current data, linked trips are estimated to be equal to 21% of daily home-based travel. Decreases in home-based travel, however, could actually be balanced by increases in multistop trips. The daily household travel forecasts do not include any nonhome-based trips; annual vehicle-miles of travel estimated for use in the energy analysis of TAPCUT policies[3] did include this additional 32% to better state the energy impacts of the policies.

6.2 GROUP TRAVEL POLICY

No actions were modeled under this policy, as the methods available did not provide sufficient basis to do any more than make parametric changes for either action in Table 1. The trip-linking action remains of great interest as an area for future development. The reduced auto ownership action could only be tested under a different approach to auto stock modeling, such as a linear or logit equation with demographic independent variables, whose coefficients could be altered.

6.3 INDIVIDUAL TRAVEL POLICY

No changes were proposed in Table 1.

7 SUMMARY

The conservation policies tested in the TAPCUT project are summarized in Table 9. This table differs from Table 1 because it shows the policies as they were tested, with all the modifications made as the TAPCUT analysis progressed. In addition, the 1990 and 2000 changes from the In-Place Policy are shown, instead of only those for the year 2000.

The costs of implementing the policies are not summarized here. Clearly cost is an important descriptor of the policies, one which will be estimated in the final report. Some general observations about cost may prove helpful, however, for understanding the policy packages as tested. The Group Travel Policy in both scenarios involves large-scale changes in transit level of service as measured by service frequency, linehaul time, and system coverage. The changes were achieved in different ways in each scenario; Scenario III used more-extensive motor bus service in mixed traffic and in exclusive lanes -- a low-capital, high-operating-cost choice.

The level of detail at which transit service changes were specified makes it difficult to summarize the changes in Table 9. The measures of the actions show that the travel time changes were of the same magnitude in each scenario. The extent of service was increased substantially over the 20-year period according to the In-Place Policy; the Group Travel Policy did not change extent of service, therefore, as much as it changed the quality of the service provided. The best measures of the transit supply under this policy in each scenario would be accessibility measures computed from the district time and cost "skim trees" (aggregate networks), a computation not completed for this study.

The actions tested under the Individual Travel Policy also varied in cost. Road construction increased in both scenarios. In Scenario I, more multilane roads were built (or rebuilt in place), whereas more two-lane roads were built in Scenario III. Under the In-Place Policy, road building is forecast to decrease from the present. Under the Individual Travel Policy, 1980 levels of construction activity are reached again in Scenario III in 2000; in Scenario I, they are exceeded by 75% in 2000. The changes to automobiles were also more costly in Scenario I than in Scenario III. Although the costs have not been computed, the Individual Travel Policy in Scenario I is probably the most expensive action when all costs are totaled.

Each policy in each scenario is briefly described below (each subsection relates to one column in Table 9). Further detail on a particular policy can be found by referring to the appropriate text on the policy action in Sections 2-6.

7.1 THE GROUP TRAVEL POLICY IN SCENARIO I

This policy test reflected no changes in land use controls or fuels/vehicles R&D compared to the In-Place Policy, but did include extensive changes in transit service, including significant improvements in light rail service and bus frequency, coupled with stringent automobile disincentives in the form of parking costs and fuel taxes. Busways were used in smaller

Table 9 TAPCUT Conservation Policies as Tested in Travel Models

Individual Conservation Action (Measure)	Forecast Year	% of In-Place Policy Value: Under Group Travel Policy: Scenario I	Under Group Travel Policy: Scenario III	Under Individual Travel Policy: Scenario I	Under Individual Travel Policy: Scenario III
Land Use Controls					
Live close to work (work trip length)	1990 2000		- 6 -14		
Increase High density zoning (growth in households relocated near/away from centers)	1990 2000		near 4.9 11.4		away 4.9 5.1
Provide decentralized work/shop locations (employment growth relocated near/away from centers)	1990 2000		near 25.8 29.3		away 16.9 17.5
Further CBD growth (CBD share of employment)	1990 2000		9.1 18.0		-6.8 -14.4
Fuels/Vehicles R&D					
Vehicle Weight R&D (average fleet car weight)	1990 2000			-3.3 -4.3	6.7 8.2
Engine/Vehicle/Fuels R&D (new car mpg)	1990 2000	2.2 2.8	1.8 -1.8	28.4 23.4	-1.4 3.6
Economic Disincentives for Autos					
Increase CBD parking cost (daily charge)	1990 2000	200 200	200 200		
Impose cost on free parking (1975 dollars)	1990 2000	\$2.00[a] \$2.00[a]	\$1.00[a] \$1.00[a]		
Increase auto fuel tax (retail fuel price)	1990 2000	37.2 97.2	38.6 42.0		
Group Travel Incentives					
Carpool promotion (parking costs, walk time to work)	1990 2000	-50 -50	-50 -50		
New rail service (track miles built)	1990 2000	235 215	1 33		
New rail service (in-vehicle time)		-40 to -60			
Express busways built (busway lane-miles)	1990 2000	same 100	164 111		
Express bus service (in-vehicle time)		-33 to -45 on busways and bus lanes			
Conventional bus service (routes with improved frequency)	1990 2000	50 100			
Conventional bus service (wait time)	1990 2000	15 15			
Reduce transit fares	1990 2000		25 25		
Auto Travel Behavior					
Trip-linking		parametric only; discuss impacts.			

[a]Actual dollar charge, not a percent value.

cities, whereas new light rail networks were built in medium-sized cities. The fuel taxes increased to 50% of the fuel price in 1990, and then 100% by 2000. Parking costs tripled in central business districts, and a base daily charge of $2.00 (1975 dollars) was imposed on parking that was free under the In-Place Policy. There were 50% reductions in carpool parking costs and in walk times to the work place for both forecast years. The fuel economy achieved by the new car purchases reflects fuel price impacts on automobile purchases and a minor vehicle design change in the medium Otto-engine vehicle.

7.2 THE GROUP TRAVEL POLICY IN SCENARIO III

Significant transit improvements with stiff increases in automobile costs marked this policy test. The transit improvements focused on increases in express bus service, extensive use of busways in medium- and small-sized cities, and reduction of fares to 75% of In-Place Policy levels. In addition, carpool parking costs and walk times were reduced by 50%. The fuel taxes reached 50% of the dealer's price in 1990 and stayed there through 2000. Parking taxes ($1.00 in 1975 dollars) were imposed throughout each metropolitan region, even in those suburban lots that were free under the In-Place Policy. Some land use controls were imposed, resulting in a net reduction in work trip length, increased residential density, and a damping of the trend under the In-Place Policy to decrease the CBD share of metropolitan employment. There were essentially no changes in the automobile characteristics defined under the In-Place Policy for this scenario.

7.3 THE INDIVIDUAL TRAVEL POLICY IN SCENARIO I

In this policy test, significant increases in automobile fuel economy were postulated. All other variables were unchanged from the In-Place Policy. New cars were 23.4% more fuel efficient than their In-Place Policy counterparts. The stock held by households was nearly 23% more efficient than the stock projected under the In-Place Policy, and 125% better than that of 1980.

The fuel economy gains for newly purchased automobiles in this policy are achieved without major weight changes. Engine design improvements in 1990 allow both performance and fuel economy to improve without much change in vehicle weight. In 2000, the need for weight change is somewhat greater, whereas the fuel economy increase over the In-Place Policy vehicles is not quite as great as for 1990.

7.4 THE INDIVIDUAL TRAVEL POLICY IN SCENARIO III

A modest improvement in auto fuel economy and an increase in decentralized development are the changes characterizing this policy test. The prices of fuel, transit, and parking are unchanged from those for the In-Place Policy. Growth in employment and households tended to occur away from established centers. About 17% of growth in employment and 5% of growth in households made these shifts, as compared with growth shifts made under In-Place Policy. Further, the share of employment in the CBD decreased more rapidly than under the In-Place Policy: it was 14% less by 2000.

Automobile fuel economy dips below the In-Place Policy value in 1990 because of a shift in consumer preference toward medium-sized and large cars. However, with the production of higher-performance cars, by 2000, the effect of the market shift has been overcome. Market preferences also result in an increased average new car weight in spite of 3-4% weight reductions for small and large cars compared to the weights projected under the In-Place Policy.

REFERENCES

1. Kaplan, M.P., Y. Gur, and A.D. Vyas, *A Sketch Planning Model for Urban Transportation Policy Analysis*, presented at 61st Annual Meeting of Transportation Research Board, Washington, D.C. (Jan. 1982).

2. Hudson, C., E. Putnam, and M. Bernard, *Vehicle Characterization for the TAPCUT Project: Performance and Cost*, Argonne National Laboratory Report ANL/EES-TM-171 (Sept. 1981).

3. Singh, M.K., *Energy Consumption Due to Local Travel by Urban Households under Three Alternative Policies: 1980-2000*, Argonne National Laboratory Report ANL/EES-TM-172 (Nov. 1981).